Reducing Death on the Road: The Effects of Minimum Safety Standards, Publicized Crash Tests, Seat Belts, and Alcohol

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ABSTRACT

Objectives. Two phases of attempts to improve passenger car crashworthiness have occurred: minimum safety standards and publicized crash tests. This study evaluated these attempts, as well as changes in seat belt and alcohol use, in terms of their effect on occupant death and fatal crash rates.

Methods. Data on passenger car occupant fatalities and total involvement in fatal crashes, for 1975 through 1991, were obtained from the Fatal Accident Reporting System. Rates per mile were calculated through published sources on vehicle use by vehicle age. Regression estimates of effects of regulation, publicized crash tests, seat belt use, and alcohol involvement were obtained.

Results. Substantial reductions in fatalities occurred in the vehicle model years from the late 1960s through most of the 1970s, when federal standards were applied. Some additional increments in reduced death rates, attributable to additional improved vehicle crashworthiness, occurred during the period of publicized crash tests. Increased seat belt use and reduced alcohol use also contributed significantly to reduced deaths.

Conclusions. Minimum safety standards, crashworthiness improvements, seat belt use laws, and reduced alcohol use each contributed to a large reduction in passenger car occupant deaths. (*Am J Public Health.* 1996;86:31–34)

Introduction

Vehicle-related deaths on US roads have declined from more than 50 000 per year to about 40 000 per year in the past 25 years, during which the numbers of registered vehicles doubled, miles driven similarly increased, and cars became smaller. The rate of deaths per hundred million vehicle miles, which was 5.5 in 1966, when the Motor Vehicle Safety Act was enacted, was 1.8 in 1992.[1]

The effects on these rates of government safety standards, which have set performance criteria for crashworthiness and crash avoidance that must be met or exceeded, and laws requiring seat belt use are disputed. Neoclassic economists argue that drivers protected by more crashworthy cars or seat belts drive more riskily, offsetting the effects of the regulations as a result of increased collisions with other road users. Claimed support for this theory is mainly based on regression analysis of ripples in various time series[2,3] or self-reported claims of seat belt use.[4] Disaggregation of data, separating regulated from unregulated vehicles, indicated incremental reductions in occupant fatalities in regulated vehicles during the late 1960s and 1970s and no adverse effect on other road users.[5–10] Self-reports of seat belt use are known to be invalid.[11,12]

Actual observations of seat belt use and driving behaviors before and after a belt use law, in comparison with observations in a jurisdiction with no law, revealed no changes in risky behaviors (e.g., speeding, running stop signs and red lights, following too closely) that suggested riskier behavior when drivers increase seat belt use.[13]

The history of federal and state efforts to reduce motor vehicle injuries provides an opportunity to estimate the effects of "minimum" safety standards, improved crashworthiness (at least partly motivated by embarrassment to manufacturers and competitive concerns caused by publicity regarding crash tests), seat belt use (increased mainly by laws requiring use), reductions of alcohol use in drivers, and potential offsetting behavior.

Adoption of safety standards virtually ceased from 1978 to 1987. The federal standard that required seat belts automatically encircling front-outboard occupants or, alternatively, air bags was rescinded by the Reagan administration and was restored in the late 1980s only after the courts ruled that the administration had acted illegally. The National Highway Traffic Safety Administration did continue frontal crash tests of a selection of cars annually and published the results. Manufacturers were embarrassed enough by the reported forces on occupant test dummies at 35 miles per hour that, on occasion, they requested a retest after modifying the vehicles.

The crash tests indicated incremental improvement in crashworthiness during the 1980s, as evidenced by reduced forces on crash test dummies. Research on fatalities to occupants in frontal crashes indicated a reduced number of deaths in frontal crashes of vehicles that performed well in crash tests,[14,15] but the research designs of these studies did not allow for the possibility of offsetting behavior. Seat belt use laws, enacted by the states from 1985 to 1990, largely accounted for more than doubling of seat belt use,[16] and

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TABLE 1—Passenger Car Fatality Rates per 100 Million Vehicle Miles: 1975 through 1977 Models, by Vehicle Age

	Rate per 100 Million Miles	
Vehicle Age, y	Occupant Deaths	Nonoccupant Deaths from Crashes
1	2.18	1.75
2	2.27	1.88
3	2.41	1.98
4	2.64	2.21
5	2.71	2.10
6	2.57	2.01
7	2.69	2.01
8	2.57	1.97
9	2.65	2.29
10	2.83	2.34
11	3.01	2.70
12	3.40	2.70
13	2.92	2.45
14	2.95	2.37
15	2.79	1.74

TABLE 2—Regression Estimation of Passenger Car Fatality Rates per 100 Million Vehicle Miles: 1961 through 1990 Cars in 1975 through 1991

	Occupant Deaths		Nonoccupant Deaths from Crashes	
	Effect	95% CI	Effect	95% CI
Standards	−0.260	−0.237, −0.283	−0.055	−0.045, −0.065
NCAP publicity	−0.077	−0.044, −0.110	−0.029	−0.009, −0.049
Seat belt use, %	−0.007	−0.001, −0.013	−0.006	−0.002, −0.010
Alcohol > 0.10, %	0.007	0.001, 0.013	0.007	0.002, 0.012
Calendar year	−0.017	−0.052, 0.019	−0.016	−0.038, 0.006
Industrial production	0.029	0.015, 0.043	0.019	0.010, 0.028
Expected from age of vehicle	0.444	0.656, 0.232	0.289	0.193, 0.385
Expected from wheelbase	1.066	0.612, 1.520	1.252	1.047, 1.551
Intercept	−0.793		−1.950	
R^2	.92		.86	

Note. CI = confidence interval; NCAP = New Car Assessment Program.

alcohol in fatally injured drivers declined about 10 percentage points during the 1980s[17] as a result of a variety of factors. The purpose of this paper is to assess the contribution of each of these changes to the reduction in passenger car fatality rates, as well as any evidence of offsetting behavior.

Data and Methods

Death rates per 100 million miles in terms of passenger cars, by model year of the vehicle and whether the death was to one or more occupants of the car, were obtained by means of several methods and data sources for model years 1961 through 1990 in each of the calendar years 1975 through 1991.* Miles per vehicle of a given age in the 1988 mileage survey were adjusted to those of other years by multiplying them by the ratio of average miles driven in other years to the 1988 average. The mileage survey included periodic calls to the same households to obtain odometer readings,[18] which is probably more valid than asking people their annual mileage. Rates were available on 254 combinations of vehicle model year and calendar year.

Two sets of rates per 100 million miles were analyzed separately: occupant fatalities and crashes fatal to nonoccupants (occupants of other vehicles in multiple-vehicle crashes, pedestrians, and bicyclists). The first allowed an estimate of the effects of safety standards, improved crashworthiness, and the other factors on all occupant deaths. The second allowed examination of the possible effects on other road users. If there is offsetting behavior, nonoccupant death rates should increase in relation to regulation, crash test publicity, and belt use.

Since some safety standards were imposed by the General Services Administration in 1966 on cars sold to the government and the standards for all cars began to be imposed in 1968, the absence of standards was correlated with vehicle age. Data on the 1975 through 1977 models were available for a full 15 years of vehicle use. The death rates (each of the two sets separately) per mile were calculated for these model years for each year of age and averaged among the three model years. These rates are presented in Table 1. Note that the death rates are neither linear nor monotonic as the vehicles age. A graph of the preregulation models by age (available from the author) indicates that the pattern of older, preregulation vehicles is similar to that of vehicles 10 years old and older in Table 1. Use of the 1975 through 1977 rate for a vehicle of a given age as the expected rate for a vehicle of that age controlled for variation attributable to vehicle age.

Other factors considered were the downsizing of vehicles and the economic conditions during a given calendar year, both of which have been correlated with death rates,[22] observed seat belt use in a given calendar year, and percentage of drivers with alcohol greater than 0.10% by weight in a given calendar year. Smaller vehicles have higher occupant death rates because of less interior space to decelerate, and, for unknown reasons, deaths per mile are marginally higher in years of greater economic prosperity. Wheelbase, the distance from the front to rear axle, has been shown to be the best predictor of differences in fatality rates due to vehicle size.[23] As a means of controlling for vehicle size, the death rates per mile in calendar year 1988 were calculated for seven categories in 5-in increments of wheelbase (from <95.1 to 120.1+); the 1988 mileage survey and decoded vehicle identification numbers for make and model of vehicle in the fatal file and mileage survey file were used in these calculations. Expected fatalities were calculated by multiplying the 1988 rate for each size by the number of vehicles of that size sold in a given model year (discounted for scrappage as they aged).[24,25] The expected number was then divided by the mileage previously estimated for each model and calendar year. The index of

*As an example of data elements in the analysis, the following are elements for 1986 model cars in calendar year 1989: miles driven by 3-year-old cars in 1988 = 10 550[18]; ratio of average miles in 1989 to average miles in 1988 = 1.03[19]; 1986 model cars registered in 1989 = 10 489 000[20]; estimated 100 million miles use = 10 550 × 1.03 × 0.10489 = 1,139.8; occupant fatalities = 2012[21] (rate = 2012/1139.8 = 1.77); nonoccupant fatal crash involvement[21] = 1025 (rate = 0.90); years since regulation began = 1986 − 1966 > 12, therefore 12; years since NCAP publicity began = 1986 − 1979 = 7; % observed belt use in 1986 models during 1989[27] = 56; % dead drivers of 1986 models in 1989 with blood alcohol > 0.10% = 31 (based on states where 80 percent or more are assayed for alcohol)[28]; Index of Industrial Production, 1989 = 106.8.[26]

industrial production was used as an indicator of economic activity. Seat belt use in a given model–calendar year was included from an annual survey of 19 cities and their environs, extrapolating for a few years in which the survey was not done.[27] Alcohol in fatally injured drivers for each model–calendar year was obtained in states that test 80% or more of such drivers.[28]

Ordinary least squares regression was used to estimate the effects of the various factors. The variable for minimum safety standards was zero for pre-1966 models, incremented from 1 to 12 in 1966 through 1977 models, and 12 for 1978 through 1991 models. As noted, the reduction in occupant death rates has been shown to be incremental in 1966 through 1977 models, partly because of the imposition of new standards in various years of that period and partly because of delays in meeting the standards in some models.[5–9,29] The publication of New Car Assessment Program (NCAP) crash test results began in 1979, so the NCAP variable was zero for 1961 through 1979 models and incremented by one (from 1 to 11 consecutively) for 1980 through 1990 models, based on the assumption that crashworthiness was improved incrementally as the crash test results for particular makes and models became known.

Results

The regression coefficients for the predictor variables are presented in Table 2. After the expected effects of vehicle age and size differences had been controlled, the incremental model years in which minimum safety standards were imposed and the model years during which NCAP tests were publicized were strong predictors of reduced occupant death rates and reduced occupant and total fatal crash rates. The improvements were larger during the period of minimum safety standards than during that of publicized crash tests. Increased seat belt use was also correlated with a reduction in occupant fatalities per mile. Higher crash rates were found in the model–calendar years in which more alcohol was found in drivers, as expected. Contrary to offsetting behavior theory, the coefficients for regulation, NCAP tests, and seat belt use were negative in relation to nonoccupant involvement rates.

In each case, rates were marginally higher in more economically prosperous years, as indicated by the predictive coefficient on the index of industrial production. When all of the other factors were controlled, the trend by calendar year was not significant. The R^2 value in each case indicated excellent fit of the data to the regression models.

Discussion

The results support the conclusion that car occupant deaths have been reduced substantially by safety standards and publicized crash tests leading to increased crashworthiness. The reductions were specific to model years in which these activities were occurring rather than to a trend by calendar year. Examination of plots of residuals from regression of the other predictor variables indicated that the effects were linear and not influenced by outliers. Increased seat belt use and reduced alcohol use had additional effects.

The fact that the reduction in deaths was largely a linear function of vehicle model year during the period of regulation and NCAP tests suggests that, in addition to meeting the standards or improvement in performance on the tests, manufacturers were devoting attention to crashworthiness generally. For example, although there is no standard for so-called "crumple zones" to better absorb energy in crashes, manufacturers have increasingly designed them into vehicles.

The fact that reductions in nonoccupant fatalities were associated with regulation, NCAP testing, and seat belt use is not anomalous. Some regulations were aimed at crash avoidance (reduced glare in drivers' eyes, side running lights). Sharp points on front ends were reduced in the 1980s when NCAP testing was being done. A general increase in seat belt use increased protection in the "other" vehicles in collisions.

The econometric analyses claiming offsetting behavior are misleading.[30] Ironically, the most recent claim of offsetting behavior by economists[3] is probably a result of the federal government's failure to regulate trucks and utility vehicles. Lack of distinction of passenger cars from pickup trucks and utility vehicles in a time-series analysis will give false results in terms of the effects of regulation on passenger cars. The reason is not that the regulated cars are more often hitting trucks and other road users, as claimed by proponents of time-series analyses, but that the government has failed to impose standards to reduce rollover of unstable pickup trucks and utility vehicles, which have grown substantially in use. The rollover rates of the less stable of these vehicles are 3 to 20 times those of passenger cars.[31–35] □

References

1. National Highway Traffic Safety Administration. *Traffic Safety Facts, 1992.* Washington, DC: US Dept of Transportation; 1994.
2. Peltzman S. The effects of automobile safety regulation. *J Pol Econ.* 1975;83:677–725.
3. Chirinko RS, Harper EP. Buckle up or slow down? New estimates of offsetting behavior and their implications for automobile safety regulation. *J Pol Anal Man.* 1993;12:270–296.
4. Garbacz C. Estimating seat belt effectiveness with seat belt usage data from the Centers for Disease Control. *Econ Let.* 1990;34:83–88.
5. Robertson LS. A critical analysis of Peltzman's 'The effects of automobile safety regulation.' *J Econ Issues.* 1977;11:587.
6. Graham JD, Garber S. Evaluating the effects of automobile safety regulation. *J Pol Anal Man.* 1984;3:206–224.
7. Robertson LS. State and federal new-car safety regulation: effects on fatality rates. *Acc Anal Prev.* 1977;9:151–156.
8. Robertson LS. Automobile safety regulations and death reductions in the United States. *Am J Public Health.* 1981;71:818–822.
9. Graham JD Technology, behavior, and safety: an empirical study of automobile occupant-protection regulation. *Policy Sci.* 1984;74:141–151.
10. Robertson LS. Automobile safety regulation: rebuttal and new data. *Am J Public Health.* 1984;74:1390–1394.
11. Waller PF, Barry PZ. *Seat Belts: A Comparison of Observed and Reported Use.* Chapel Hill, NC: University of North Carolina Highway Safety Research Center; 1969.
12. Robertson LS. The validity of self-reported behavioral risk factors: seatbelt and alcohol use. *J Trauma.* 1992;32:58–59.
13. Lund AK, Zador PL. Mandatory belt use and driver risk taking. *Risk Anal.* 1984; 4:41–53.
14. Kahane CJ. *Correlation of NCAP Performance with Fatality Risk in Actual Head-On Collisions.* Washington, DC: National Highway Traffic Safety Administration; 1994.
15. Zador PL, Jones IS, Ginsburg M. Fatal front-to-front car collisions and the results of 35 MPH frontal barrier impacts. In: *28th Annual Proceedings of the Am. Assn. Auto. Med.*, Denver, Colo: 1984.
16. Datta TK, Guzek P. *Restraint System Use in 19 U.S. Cities: 1989 Annual Report.* Washington, DC: US Dept of Transportation; 1990.
17. Klein TM, Burgess M. *Alcohol Involvement in Fatal Crashes—1992.* Washington, DC: National Highway Traffic Safety Administration; 1994.
18. Energy Information Administration. *Household Vehicles Energy Consumption, 1988.* Washington, DC: US Dept of Energy; 1990.
19. Federal Highway Administration. *Highway Statistics.* Washington, DC: US Dept of Transportation; 1975–1992.
20. *Ward's Automotive Yearbook.* Detroit, Mich: Ward's Communications; 1960–1992.

21. National Highway Traffic Safety Administration. *FARS 91.* Washington, DC: US Dept of Transportation; 1993.
22. Robertson LS. *Injury Epidemiology.* New York, NY: Oxford University Press Inc; 1992.
23. Robertson LS. How to save fuel and reduce injuries in automobiles. *J Trauma.* 1991;31:107–109.
24. Flammang JM. *Standard Catalog of Imported Cars, 1946–1990.* Iola, Wis: Kraus Publications; 1992.
25. *Automotive News Almanac Issue.* Detroit, Mich: Automotive News Inc; 1960–1992.
26. *Economic Indicators.* Washington, DC: Council of Economic Advisors; 1994.
27. National Highway Traffic Safety Administration. *Restraint System Use in the Traffic Population.* Washington, DC: US Dept of Transportation; 1975–1991.
28. National Highway Traffic Safety Administration. *Fatal Accident Reporting System 1988.* Washington, DC: US Dept of Transportation; 1989.
29. National Highway Traffic Safety Administration. *Standards Enforcement Tests Reports Index.* Washington, DC: US Dept of Transportation; 1969–1980.
30. Leamer EE. Let's take the con out of econometrics. *Am Econ Rev.* 1983;73:31–43.
31. Snyder RG, McDole TL, Ladd WM, Minahan DJ. *On-Road Crash Experience of Utility Vehicles.* Ann Arbor, Mich: University of Michigan Highway Safety Research Center, 1980.
32. Reinfurt DW, Li LK, Popkin CL, O'Neill B, Burchman PF, Wells JAK. *A Comparison of Crash Experience of Utility Vehicles, Pickup Trucks and Passenger Cars.* Chapel Hill, NC: University of North Carolina Highway Safety Research Center; 1981.
33. Robertson LS. Risk of fatal rollover in utility vehicles relative to static stability. *Am J Public Health.* 1989;79:300–303.
34. Jones IS, Penny MB. *Engineering Parameters Related to Rollover Frequency.* Warrendale, Pa: Society of Automotive Engineers; 1990.
35. Harwin EA, Brewer HK. Analysis of the relationship between vehicle rollover stability and rollover risk using the NHTSA CARDfile Accident Database. *J Traf Med.* 1990;18:109–122.